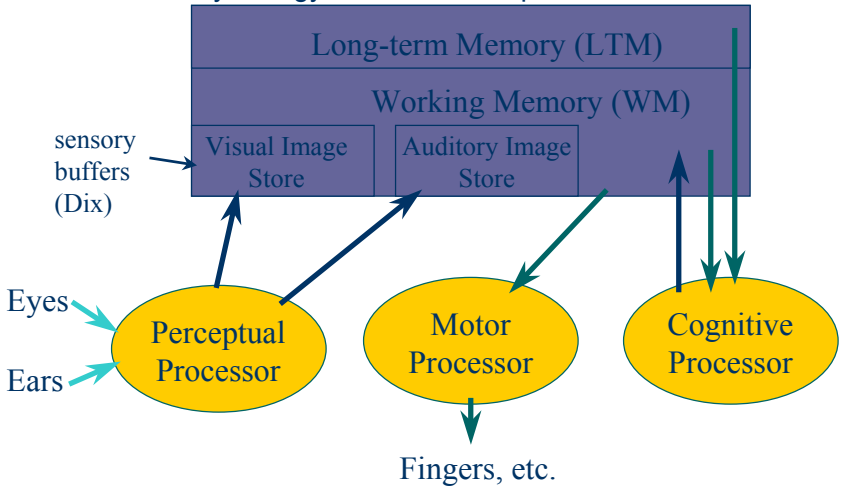
CS 544
Human Abilities

Human Information Processing
Memory, Chunking & Phrasing, Modes

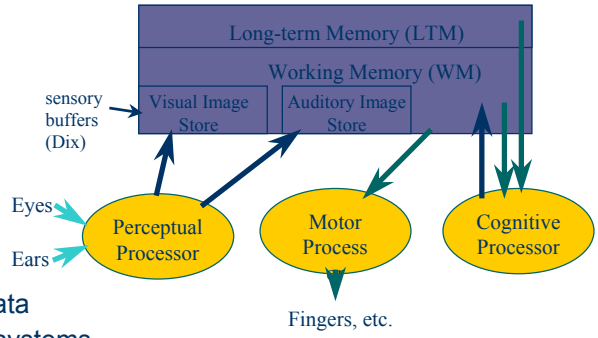
Acknowledgement: Some of the material in these lectures is based on material prepared for similar courses by Saul Greenberg (University of Calgary), Ravin Balakrishnan (University of Toronto), James Landay (University of California at Berkeley), monica schraefel (University of Toronto), and Colin Ware (University of New Hampshire). Used with the permission of the respective original authors.

Model Human Processor (MHP)

- Developed by Card, Moran, & Newell
  - The Psychology of Human-Computer Interaction, 1983

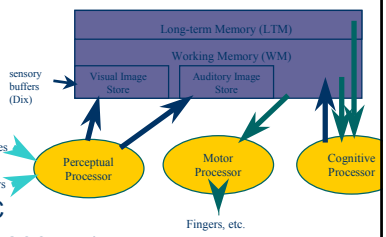


MHP Basics



- Based on empirical data
- Three interacting subsystems
  - perceptual, motor, cognitive
- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
    - pressing key in response to light
    - driving, reading signs, & hearing at once
- Parameters
  - processors have cycle time (T) ~ 100-200 ms
  - memories have capacity, decay time, & type (physical, acoustic, visual, semantic)

Memory



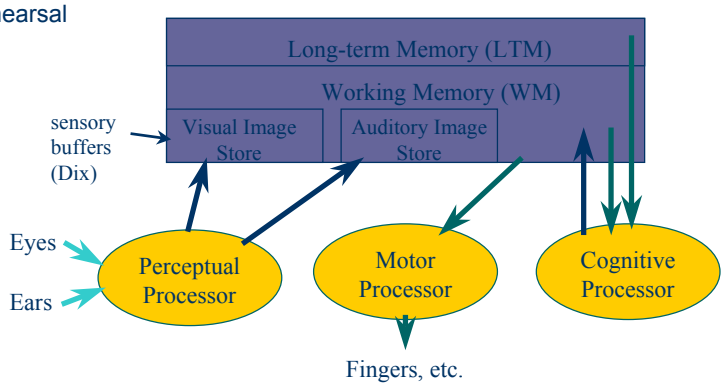
- Working memory (short term)
  - activated elements of LTM
  - small capacity (7 ± 2 “chunks”)
    - 6174591765 vs. (617) 459-1765
    - DECIBMGMC vs. DEC IBM GMC
  - rapid access (~ 70ms) & decay (~200 ms)
    - pass to LTM after a few seconds
- Long-term memory
  - huge (if not “unlimited”)
  - slower access time (~100 ms) with little decay

MHP Principles of Operation

- Recognize-Act Cycle of the Cognitive Processor (analogous to fetch-execute cycle in computers)
  - on each cycle contents in WM initiate actions associatively linked to them in LTM (“recognize”)
  - actions modify the contents of WM (“act”)
- Discrimination Principle
  - retrieval is determined by candidates that exist in memory relative to retrieval cues
  - interference: other memory chunks may be more strongly activated by the associations used as retrieval cues
- Variable Cognitive Processor Rate Principle
  - CP cycle time T_c is shorter when greater effort is induced by increased task demands/information
  - also decreases with practice

What’s missing from MHP?

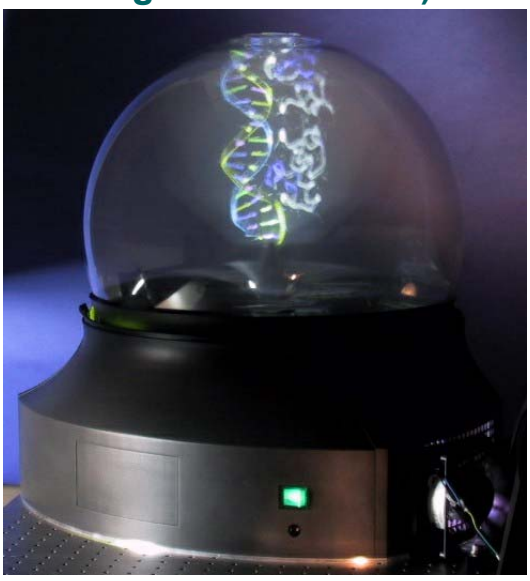
- Haptic memory
  - for touch
- Moving from sensory memory to WM
  - attention filters stimuli & passes to WM
- Moving from WM to LTM
  - rehearsal



Perception

- Stimuli that occur within one PP cycle fuse into a single concept
  - frame rate necessary for movies to look real?
    - time for 1 frame < Tp (100 msec) -> 10 frame/sec.
    - for some Tp < 100 msec -> 20 frame/sec
  - max. morse code rate can be similarly calculated

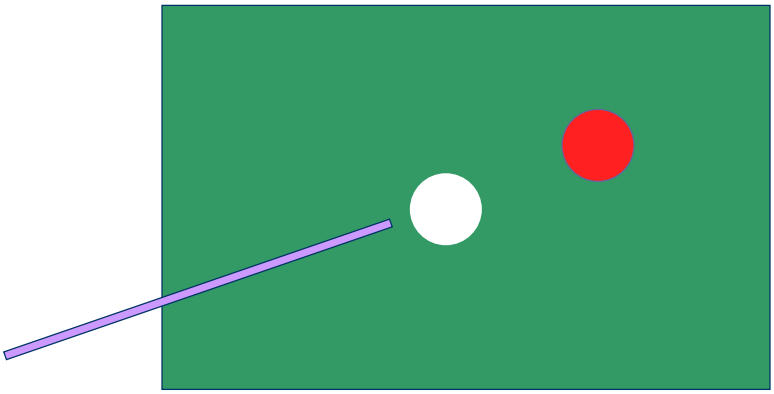
Volumetric Display (fusing of 2D images to create 3D)



Perception

- Perceptual causality
  - two distinct stimuli can fuse if the first event appears to *cause* the other
  - events must occur in the same cycle

Perceptual Causality



- How soon must red ball move after cue ball collides with it?
  - must move in < Tp (100 msec)

Simple experiment

- Volunteer
- Start saying **colors** you see in list of words
  - when slide comes up
  - as fast as you can
- Say “done” when finished
- Everyone else time it…

Green
White
Yellow
Red
Black
Blue

Simple Experiment …

- Do it again…

Paper
Back
Home
Schedule
Change
Page

Simple Experiment …

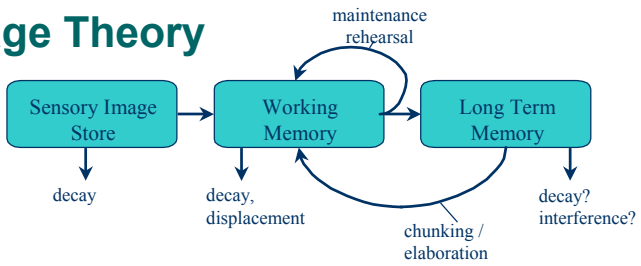
- Do it again…

Blue
Red
Black
White
Green
Yellow

Memory

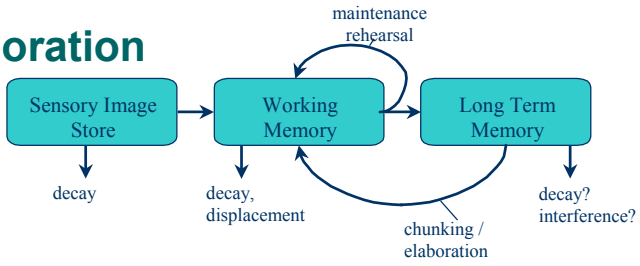
- Interference
  - two strong cues in working memory
  - link to different chunks in long term memory
- Why learn about memory?
  - know what's behind many HCI techniques
  - helps you understand what users will "get"
  - aging population of users

Stage Theory



- Working memory is small
  - temporary storage
    - decay
    - displacement
- Maintenance rehearsal
  - rote repetition
  - not enough to learn information well
- Answer to problem is organization
  - Faith Age Cold Idea Value Past Large
  - In a show of faith, the cold boy ran past the church

Elaboration



- Attach meaning (make a story)
  - e.g., sentences
- Visual imagery
- Organize (chunking)
- Link to existing knowledge, categories

Forgetting in Long Term Memory

- Causes for not remembering an item?
  - 1) never stored: encoding failure
  - 2) gone from storage: storage failure
  - 3) can't get out of storage: retrieval failure

- Interference model of forgetting
  - one item reduces ability to retrieve another
  - proactive interference (3)
    - earlier learning reduces ability to retrieve later info
    - e.g., drive to your old house instead of the new one
  - retroactive interference (3 & 2)
    - later learning reduces the ability to retrieve earlier info
    - e.g., change telephone numbers, can't remember the original

Recognition over Recall

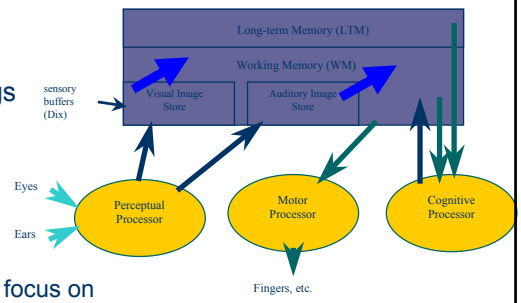
- Recall
  - info reproduced from memory
- Recognition
  - presentation of info provides knowledge that info has been seen before
  - easier because of cues to retrieval
- E.g., Command line (recall) vs. GUI (recognition) interfaces
- (remember Nielson's Heuristic #6)

Facilitating Retrieval: Cues

- Any stimulus that improves retrieval
  - example: giving hints
  - other examples in software?
    - icons, labels, menu names, etc.
- Anything related to
  - item or situation where it was learned
- Can facilitate memory in any system
- What are we taking advantage of?
  - recognition over recall!

Attention

- Filter in brain
  - Focus on certain things
  - Ignore the rest



- 3 types
  - Selective
    - Choose one thing to focus on
  - Divided
    - Try to focus on more than 1 thing at once
  - Captured
    - Stimuli that gets peoples attention

Selective Attention

- Pick one thing to focus on, amongst many possibilities
- Eye movement to item of interest
- Head movement to sounds of interest

- Cocktail party effect
  - Ability to “tune out” numerous conversations in same vicinity and focus on just one

- Single “locus of attention”

Divided Attention

- Do multiple tasks
  - Either “simultaneous”
    or time multiplexed (rapidly alternate)
- Can degrade performance
  - If combined tasks exceed human abilities
- Interference between tasks

Chunking & UI Design

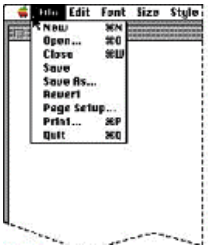
- Remember: 7±2
- Create cognitive chunks:

- Progress from general to specific

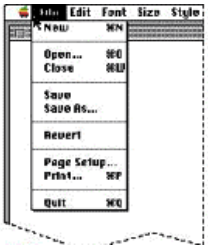
Menubar example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml

Chunking & UI Design

- Chunking menus:



Not enough groups



Too many groups

Just right?

Menubar example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml

Chunking & UI Design

- Visual separation
  - Use whitespace to separate info into groups
- Visual differentiation
  - Change visual characteristics of different groups to cause chunking
- Visual progression
  - Rely on visual and cognitive cues to guide order in which users internalize information

button example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml

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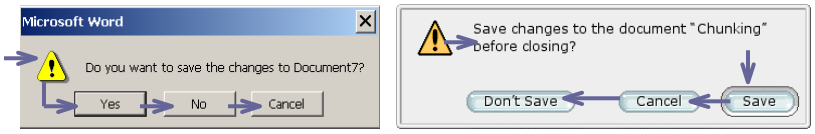


Dialog box example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml

Gestures

- Sequence of actions completed automatically once set in motion
  - E.g., typing the word "the"
    - Single gesture for experienced typist
    - Three gestures for novice typist
  - E.g., keying in phone numbers, passwords
- Haptic analogue to cognitive chunking
- UI guideline: facilitate gestures/phrases that result in haptic chunking

Modes

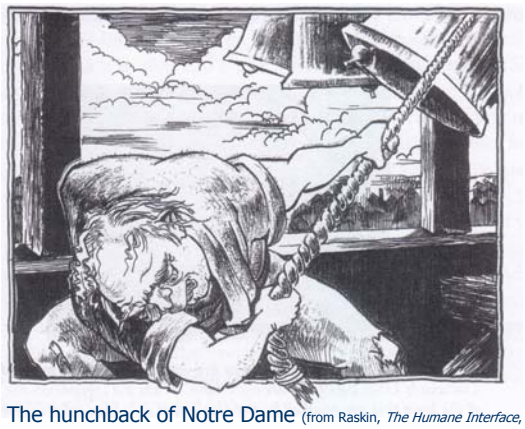
- Relates to how interfaces responds to a given gesture
  - In a mode if interpretation of a gesture is constant
  - In a different mode if gesture interpreted differently
  - E.g., tapping “Enter” key
    - Inserts return character into text in one mode
    - executes a command in another mode
- Can be troublesome
  - E.g., CapsLock key
    - !@#$@#%
  - Causes “mode errors”

Minimizing mode errors

- Do not have modes!
- Ensure modes distinctively marked
- Ensure commands required in different modes are different
  - i.e., gesture issued in a wrong mode will not result in difficulty

Quasimodes

- Kinesthetically maintained modes
  - e.g., holding shift key rather than CapsLock
  - do not cause mode errors



The hunchback of Notre Dame (from Raskin, *The Humane Interface*, pg 55)

Noun-Verb vs. Verb-Noun dialogues

- E.g., change font of a paragraph of text
- 2 ways to do it:
  - Choose *verb* (change font) first
    Then select *noun* (paragraph) to which verb applies

  or

  - Choose *noun* first, then apply *verb*

- What's the difference?

Noun-Verb interaction preferred (sometimes called *Selection-Action)*

- Error reduction
  - Verb-noun is modal.
    - Once command (verb) is selected, it effects next selection (noun). If there's a delay between actions, and wrong selection made, results can be surprising
  - Noun-verb is non-modal
    - Command (verb) executed immediately when issued

Noun-Verb interaction preferred

- Speed
  - Attention remains on item of interest
    - First on content/selection (noun), then on action (verb)
      - (in verb-noun, attention moves from content to action and back to content again. Noun-verb uses one less attention switch)
- Simple & Reversible
  - No escape/cancel operation needed
    - (in verb-noun, if you issue a command and want to cancel it, have to explicitly issue cancel operation. In noun-verb, just select something else).
- Is noun-verb always possible?

Readings

- Dix A., J. et al. (1993). Human-Computer Interaction, Second Edition. Sections 1.1 and 1.3.

- Buxton, W. (1986). Chunking and Phrasing and the design of human-computer dialogues (Reprinted in BGBG, 494-499).